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(54) **Method and apparatus for treating or ultilizing a hot gas flow**

Verfahren und Vorrichtung zur Behandlung oder zur Verwendung eines Heissgasstromes

Procédé et dispositif pour le traitement ou l'utilisation d'un courant de gaz chaud

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(73) Proprietor:
Foster Wheeler Energia Oy
00440 Helsinki (FI)

(72) Inventors:
- **Hiltunen, Matti**
  SF-48600 Karhula (FI)
- **Hyppänen, Timo**
  SF-48710 Karhula (FI)
- **Westerlund, Kurt**
  SF-00150 Helsinki (FI)

(74) Representative:
Füchsle, Klaus, Dipl.-Ing. et al
Hoffmann Eitle,
Patent- und Rechtsanwälte,
Arabellastrasse 4
81925 München (DE)

(56) References cited:

EP-A- 0 094 795	EP-A- 0 282 777
FI-A- 913 416	GB-A- 796 914

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Description

[0001] The present invention relates to a method and apparatus for cooling or utilizing hot gas in a reactor in which the lower section of the reactor is provided with a hot gas inlet and a chamber encompassing a fluidized bed, the middle section is provided with a riser, and the upper section with a gas outlet, and the reactor has heat transfer surfaces for recovering heat form solid particles. The invention especially relates to a method, in which hot gas is introduced through the inlet into the lower section of the reactor, and solid particles from the bubbling fluidized bed are fed to the inlet gas for cooling thereof, solid particles are separated from the cooled gas and returned to the fluidized bed, heat is recovered from the separated solid particles, and the cooled gas is discharged through the gas outlet.

[0002] Fluid bed reactors are well applicable to cooling of hot gases containing molten and/or vaporized components and/or tar-like particles. Gas coolers are suited to, e.g., cooling of exhaust gases from industrial plants and dry purification of gases containing dust and tar and other condensing components, which gases have resulted from partial oxidation of biomass, peat or coal. The hot gases introduced into the reactor are efficiently cooled by mixing solid particles therewith, such solid particles having been cooled in the reactor earlier.

[0003] Finnish patent 64997 teaches cooling of hot gases in circulating fluidized bed reactors. Here hot gases are fed as fluidizing gas into the mixing chamber of the reactor, where the gases cool efficiently as they come into contact with a large amount of solid particles, i.e., bed material. Solid particles are carried by the gas flow through the riser into the upper section of the reactor, where they are separated and then returned to the fluidized bed in the mixing chamber. In the riser, the gas flow conveying solid particles is cooled by heat transfer surfaces.

[0004] A drawback of the method described above is, however, that the hot gases to be cooled have to fluidize a large amount of solid particles, whereby the power requirement is high. On the other hand, a sudden interruption in the power supply may result in the entire bed flowing through the inlet and further out of the reactor.

[0005] Finnish patent application 913416 (DE-A-4 023 060 defining the method and apparatus of the preambles of claims 1 and 10) also teaches cooling of hot process gas in a stationary fluidization, i.e., a so-called bubbling fluidized bed. Here the hot gas flowing into the reactor is supplied with solid particles as an overflow from the bubbling fluidized bed. The gas and the solid particles entrained therewith flow into a dust collector disposed above the bubbling fluidized bed, wherefrom solid particles then drop back onto the surface of the bubbling fluidized bed as the flow rate of the gas quickly decreases. The bubbling fluidized bed and the gas riser, which is disposed above the dust collector, are provided with heat transfer surfaces.

[0006] In the arrangement described above, the particles fallen onto the surface of the bubbling fluidized bed are fast carried along the surface back to the overflow point, where they are immediately taken to recirculation ending up in the dust collector. Thus, a separate "surface circulation" of hot particles is developed above the fluidized bed. These particles do not cool efficiently in the fluidized bed because the particles which are deeper down in the fluidized bed, near the heat transfer surfaces, cannot mix efficiently with the particles present in the "surface circulation".

[0007] In the method described above, the riser is considered a natural place for the heat transfer surfaces because the solids and gas flows are swift therein. The gas stream, however, causes wear of the heat transfer surfaces in the riser. Wear is partly attributable to the composition of the gas as well as to the dust contained therein and partly to the high flow rate of the gas.

[0008] In some cases, the hot gas flowing to the reactor may cause fouling and clogging of the heat transfer surfaces when the gas may enter the heat transfer surfaces too hot. If the hot gas does not cool until it touches the heat transfer surfaces, the impurities will correspondingly condense on or adhere to these surfaces, and not on the circulating mass particles as is normally intended.

[0009] Especially the chlorine-containing gases cause corrosion in hot conditions and, therefore, superheating of steam to high temperatures is not usually possible in the heat transfer surfaces of the riser, whereas SO_3 may cause problems with the heat transfer surfaces at low temperatures.

[0010] It is an object of the present invention to provide an improved method and apparatus, when compared with the above-described ones, for cooling or utilizing hot gases in the hot gas treatment of solid material.

[0011] It is especially an object to provide a method and apparatus for minimizing power consumption and wear of the heat transfer surfaces.

[0012] It is another object of the present invention to provide a method and apparatus by means of which the heat energy released by the hot gas when it cools may be utilized as efficiently as possible, e.g., for generation of superheated steam.

[0013] These objects are solved according to the present invention by a method comprising the features of claim 1 and an apparatus comprising the features of claim 10. Detailed embodiments are defined in the dependent claims.

[0014] According to a preferred embodiment of the invention, solid particles may be conveyed as an overflow from the bubbling fluidized bed and directed toward the hot gas flowing through the inlet. On the other hand, the wall between the hot gas inlet and the chamber encompassing the fluidized bed may be provided with openings wherethrough solid particles are introduced into the hot gas flow. Due to a higher static pressure of

the fluidized bed, solid material automatically flows through the openings to the hot gas flow, but it may also be conveyed by a transporting gas through the openings into the gas flow.

[0015] In the reactor according to the invention, hot gas is cooled to a substantially lower temperature immediately at the gas inlet by mixing cooled solid particles with the gas, whereby the gas cools and the solid particles are correspondingly heated. Besides cooling of gases, the invention may be employed in processes where solid material is heated with hot gases, such as, e.g., heating of lime with hot gases.

[0016] In a reactor according to the invention, gas may also be cooled in the riser, whereby the riser is defined by cooled surfaces, such as for example superheating panels. In the upper section of the reactor, solid particles are separated in a particle separator from the gas which is then exhausted from the reactor. The solid particles are conveyed as a dense suspension, almost as a plug flow, via the return duct back to the bubbling fluidized bed. In the return duct are preferably disposed heat recovery surfaces for recovering the heat energy released by heated solid particles, the heat recovery surfaces being preferably arranged in the dense suspension area.

[0017] The return duct is a favourable location for heat transfer surfaces because the particle density is relatively high there, which is beneficial in respect of heat transfer, and because the return duct contains much fewer corrosive gaseous components than, e.g., the riser. Neither does hot gas containing molten or condensing components, which might clog the heat transfer surfaces, flow into the return duct.

[0018] Heat transfer surfaces may also be disposed in the fluidized bed itself, where flowing is slow and thereby favourable for the durability of the heat transfer surfaces.

[0019] A portion of the solid particles which are first carried upwardly entrained with the gas, flows down along the riser walls, back to the lower section of the reactor. This portion is partly cooled provided that the wall is a cooling surface. Cooling of the solid particles may be further improved by providing the lower section of the wall with a pocket which collects the solid particles flowing down along the wall and then leads them to the lower section of the return duct, preferably to a place equipped with heat transfer surfaces. Thus, also a portion of those solid particles which the gas is not capable of carrying as far as to the particle separators, is subjected to efficient heat transfer.

[0020] The method and apparatus according to the invention provides a simple arrangement for minimizing wear of heat transfer surfaces in the gas cooler. At the same time, power consumption is lowered in comparison with other arrangements used. Furthermore, in the arrangement according to the invention, the heat energy released by the gases is well utilized, e.g., by generating superheated steam.

[0021] The invention will be described in more detail, by way of example, with reference to the accompanying drawings, in which

- Fig. 1 is a schematic illustration of a reactor arrangement according to the invention;
- Fig. 2 is a schematic illustration of a second reactor arrangement according to the invention; and
- Fig. 3 is a schematic illustration of a third reactor arrangement according to the invention.

[0022] Fig. 1 illustrates a reactor 10 for cooling or utilizing hot process gases. The reactor 10 comprises an annular chamber 12 which has an open top and which is disposed in the lower section of the reactor. The chamber has an outer part 12' and an inner part 12" and is provided with a bubbling fluidized bed 14. In the centre of the annular chamber is disposed an inlet duct or conduit 16 for hot gases, the top edge 18 of which equals the bubbling fluidized bed top surface 20.

[0023] On top of the chamber 12 is arranged a cylindrical riser 22 of the reactor, the diameter of the riser being larger than that of the inlet duct 16 but smaller than that of the annular chamber 12. The cylindrical riser 22 is defined by cooling panels 24. The upper part of the riser is provided with openings 26, which bring the riser into contact with particle separators 28, which are structurally integrated with the riser. The inlet duct or conduit 16, chamber 12, and riser 22 may naturally be square, rectangular or in some other shape. In the embodiment of Fig. 1, the walls of the riser extend down to the fluidized bed. In some arrangements, the walls may end a little bit above the fluidized bed.

[0024] The particle separators 28 form an annular space around the cylindrical riser 22. The riser walls 24 constitute the inner walls of the particle separators. The particle separators are cyclone separators, where gas outlets 30 and inlet 26 provide a vortex flow per each outlet. The lower section 34 of the particle separator is in communication with a return duct 36, which connects the particle separator with the fluidized bed 14. The return duct forms an annular slot around the riser. The wall 24 of the riser 22 constitutes the inner wall of the return duct. The outer wall 38 of the particle separator, outer wall 40 of the return duct and outer wall 42 of the annular chamber 12 may all be of one and the same construction, e.g., membrane panel, which has been bent to a desired shape.

[0025] The return duct 36 is provided with heat transfer surfaces 44. The fluidized bed 14 is also provided with heat transfer surfaces 46.

[0026] The reactor functions so that hot gas 48 is introduced into the reactor through an inlet duct 16, which hot gas is mixed with cooled solid particles by flowing these as an overflow 50 over the inlet duct edges 18. The hot gas cools very quickly by releasing heat energy to solid particles.

[0027] The gas and solid particles entrained therewith

flow as a suspension upwardly in the riser 22. A portion of the particles is separated from the gas and flows along walls 24 back to the fluidized bed, simultaneously releasing heat energy to the walls. The gas suspension flows via inlet opening 26 to the particle separator 28, where solid particles are separated from the gas. Purified and cooled gases are led out of the reactor through the outlet 30.

[0028] The separated solid particles are allowed to flow by gravity downwardly in the return duct 36. Solid particles cool while releasing part of their heat energy in the heat exchanger 44. Solid particles further cool in the fluidized bed by the effect of the heat exchanger 46.

[0029] Appropriate fluidizing, in respect of both overflow and heat transfer, is maintained in the fluidized bed by leading fluidizing air or fluidizing gas through nozzles 52 into the annular chamber. The amount of solid particles in the reactor may be regulated by adding particles via conduit 54 or by discharging them via conduit 56.

[0030] Fig. 2 illustrates a second way of applying the arrangement of the invention. Corresponding items of Figs. 2 and 1 are denoted with the same reference numerals. Fig. 2 especially shows another arrangement for leading solid particles from the fluidized bed 14 into the hot gas inlet duct and a new arrangement for leading the particles flowing along the riser walls 24 into the fluidized bed 14.

[0031] The hot gas inlet duct 16 is provided with openings 60 wherethrough solid particles from the fluidized bed flow into the inlet duct. The pressure difference between the fluidized bed 14 and the inlet duct 16 functions as a carrying force. The particles flowing into the inlet duct are immediately mixed with the hot gas and are carried therewith up into the riser 22.

[0032] The wall 24 of the riser 22 is provided with an internal pocket 62 which is connected with the return duct 36 via an opening 64. In the riser, a portion of the particles flowing upwardly with the gases loses their speed and starts to flow downwardly along walls 24. These particles end up in the pockets 62, wherefrom they may be led via openings 64 into the return duct. In the return duct, the particles cool efficiently while passing by the heat transfer surfaces 44. By this arrangement it is possible to intensify the cooling of particles if the capability of the heat transfer surfaces of the walls 24 is insufficient for cooling the particles.

[0033] In the arrangement shown in Fig. 2, the cross section of the inlet duct 16 for hot gases has the shape of an elongated slot. Correspondingly, the cross section of the riser has the shape of an elongated rectangle, and the fluidized bed 14 is arranged in two rectangular chambers which are of the same length as the substantially slot-shaped inlet duct 16 and which are disposed on both sides thereof. The particle separators 28 are also rectangular in cross section, and they are parallel with the riser and arranged on both sides thereof.

[0034] Fig. 3 illustrates a third exemplary way of applying the arrangement of the invention for treating hot gases. Items corresponding to those of Fig. 1 are denoted with the same reference numerals. Differently from the arrangement shown in Fig. 1, the riser 22 in Fig. 3 is of a fire tube construction. The riser is provided with two horizontal tube plates 70 and 72, which are similar to the cross section of the riser in shape. Between the tube plates are disposed ducts 74 to connect the riser space 76 below the tube plates with the riser space 78 above the tube plates. The free space between the ducts 74 is filled with heat transfer medium, such as water or air.

[0035] In the arrangement of Fig. 3, the gas suspension produced in the lower section of the riser is conveyed through ducts 74 to the upper section 78 of the riser. The gas suspension flowing in the ducts is cooled indirectly with heat transfer medium. By employing the fire tube arrangement, cooling of solid material may be intensified already in the riser, especially in low pressure arrangements.

[0036] It is not an intention to limit the invention to the examples described above, but, on the contrary, to apply it to different modifications within the scope of invention defined by the accompanying claims.

Claims

1. A method of cooling hot gas in a reactor (10) in which

   - the lower section of the reactor is provided with a hot gas inlet duct (16) and a chamber (12) encompassing a bubbling fluidized bed (14), the middle section is provided with a riser (22) defined by walls (24), and the upper section with a particle separator (28) and a gas outlet (30), and the reactor has heat transfer surfaces (24, 44, 46) for recovering heat from solid particles, whereby
   - hot gas is introduced through the inlet duct (16) into the lower section of the reactor,
   - solid particles from the bubbling fluidized bed (14) are fed into the hot gas for cooling thereof,
   - solid particles are separated from the thus cooled solids containing gas and returned to the bubbling fluidized bed,
   - cooled solids-containing gas is conveyed through the riser (22) into the upper section of the reactor, where solid particles are separated from the gas in the particle separator (28) and returned to the bubbling fluidized bed,
   - heat is recovered from separated solid particles in the bubbling fluidized bed, and
   - cooled gas is discharged from the reactor via the gas outlet (30), characterized in that

   said riser walls (24) are arranged such that a lower portion thereof partly divides the bubbling fluidized bed into an outer and an inner part, whereby

- solid particles, which are transported through the riser into the upper section of the reactor and separated from the cooled gas in the particle separator in the upper section of the reactor, are caused by said riser walls (24) to return to the outer part of the bubbling fluidized bed and to be fed into the hot inlet gas after said particles have travelled from said outer part (12') of the bubbling fluidized bed to the inner part (12") of the bubbling fluidized bed, and
- heat is recovered from solid particles by heat transfer surfaces disposed in the travelling path of the solid particles being transported through the riser (22), the particle separator (28), a return duct (36) and the outer part (12') of the bubbling fluidized bed (14) to the inner part (12") of the bubbling fluidized bed.

2. A method as recited in Claim 1, characterized in that solid particles from the inner part (12") of the fluidized bed are fed as an overflow over an edge (18) into the hot gases.

3. A method as recited in claim 1, **characterized in that** solid particles from the inner part (12") of the fluidized bed are introduced into the hot gases through openings (60) of the inlet duct by employing a transporting gas.

4. A method as recited in claim 1, **characterized in that** solid particles are cooled on heat transfer surfaces (44) disposed in the return duct (36).

5. A method as recited in claim 1, **characterized in that** solid particles are cooled on heat transfer surfaces (46) in the fluidized bed (14).

6. A method as recited in claim 5, **characterized in that** solid particles are cooled on heat transfer surfaces (46) in the outer part (12') of the bubbling fluidized bed.

7. A method as recited in claim 1, **characterized in that** the gas flow is conducted from the riser (22) into two, preferably a plurality of particle separators (28), wherefrom the separated solid particles are returned via two, preferably a plurality of return ducts (36) to the bubbling fluidized bed (14).

8. A method as recited in claim 1, **characterized in that** the gas flow is introduced through the inlet duct (16) into the lower section of the reactor at the level equal to or above the level of nozzles (52) for introducing fluidization gas into the fluidized bed (14).

9. A method as recited in claim 8, **characterized in that** the gas flow is introduced through the inlet duct (16) into the lower section of the reactor at the level equal to-the level of nozzles (52) for introducing fluidization gas into the fluidized bed (14).

10. An apparatus for cooling hot gases in a reactor (10) in which the lower section of the reactor is provided with a hot gas inlet duct (16) and a chamber (12) encompassing a fluidized bed, the middle section is provided with a riser (22), and the upper section with a gas outlet (30), and the reactor has heat transfer surfaces (24, 44, 46) for recovering heat from solid particles,
characterized in that
the reactor comprises

- a riser (22) defined by walls (24) and being arranged above the bubbling fluidized bed (14) so that the lower portion of the riser walls (24) partly divides the fluidized bed into an outer (12') and inner (12") part,
- at least one particle separator (28) arranged in the upper section of the reactor,
- at least one return duct (36) to connect the particle separator (28) with the outer part (12') of the fluidized bed, for returning the solid particles separated in the particle separator to the outer part of the fluidized bed, and
- heat transfer surfaces disposed in the travelling path of the solid particles as defined by the riser, the particle separator, the return duct and the outer part of the fluidized bed and the inner part of the fluidized bed.

11. An apparatus as recited in Claim 10,
characterized in that
the return duct (36) is structurally connected with the riser (22) so that the riser wall (24) constitutes part of the return duct wall.

12. An apparatus as recited in claim 10, characterized in that the upper section of the chamber (12) encompassing the fluidized bed (14) has the shape of an open vat.

13. An apparatus as recited in claim 10, **characterized in that** the bubbling fluidized bed (14) is arranged in the annular chamber encasing the gas inlet duct (16).

14. An apparatus as recited in claim 13, **characterized in that** the riser (22) is cylindrical and that the return duct (36) forms a narrow annular space around the riser.

15. An apparatus as recited in claim 10, **characterized in that** the gas inlet duct (16) is a narrow rectangular slot and that the bubbling fluidized bed is contained in the elongated vat (12) disposed adjacent to the narrow slot.

16. An apparatus as recited in claim 10, **characterized in that** the bubbling fluidized bed is contained in the elongated vats disposed on both sides of the narrow slot.

17. An apparatus as recited in claim 10, **characterized in that** the inner part (12") of the bubbling fluidized bed is provided with means (18) for conveying solid particles as an overflow into the hot inlet gas.

18. An apparatus as recited in claim 10, **characterized in that** inner part (12") of the bubbling fluidized bed is provided with means for conveying solid particles by a transporting gas via inlet openings (60) into the hot inlet gas.

19. An apparatus as recited in claim 10, **characterized in that** the outer part (12') of the fluidized bed is provided with heat transfer surfaces (46) for cooling solid particles.

20. An apparatus as recited in claim 10, **characterized in that** the particle separator (28) is connected with the riser (22) by common wall constructions.

21. An apparatus as recited in Claim 10, **characterized in that** the hot gas inlet duct (16) is extending into the chamber (12) to the level equal to or above the level of nozzles (52) for introducing fluidization gas into the fluidized bed (14).

22. An apparatus as recited in Claim 21, **characterized in that** the hot gas inlet duct (16) is extending into the chamber (12) to the level equal to the level of nozzles (52) for introducing fluidization gas into the fluidized bed (14).

23. An apparatus as recited in Claim 10, **characterized in that** heat transfer surfaces (44) are provided in the return duct (36) for cooling solid particles.

24. An apparatus as recited in Claim 10, **characterized in that** heat transfer surfaces (24, 74) are associated with the riser (22) for cooling solid particles.

Patentansprüche

1. Verfahren zur Abkühlung von Heißgasen in einem Reaktor (10), wo

   - der untere Bereich des Reaktors mit einem Heißgaseinlaßkanal (16) und einer Kammer (12) versehen ist, die ein Brodelbett (14) einschließt, der mittlere Bereich mit einem durch Wände (24) gebildeten Steigrohr (22), und der obere Bereich mit einem Partikelabscheider (28) und einem Gasauslaß (30) versehen ist, und der Reaktor Wärmeübertragungsflächen (24, 44, 46) zur Rückgewinnung von Wärme aus Feststoffpartikeln aufweist, wobei
   - Heißgas durch den Einlaßkanal (16) in den unteren Bereich des Reaktors eingeführt wird,
   - Feststoffpartikel aus dem Brodelbett (14) in das Heißgas zur Abkühlung desselben eingeführt werden,
   - Feststoffpartikel aus dem auf solche Weise abgekühlten, feststoffhaltigen Gas abgeschieden und dem Brodelbett rückgeführt werden,
   - abgekühltes feststoffhaltiges Gas durch das Steigrohr (22) in den oberen Bereich des Reaktors befördert wird, wo Feststoffpartikel im Partikelabscheider (28) aus dem Gas abgeschieden und dem Brodelbett rückgeführt werden,
   - Wärme aus abgeschiedenen Feststoffpartikeln in dem Brodelbett zurückgewonnen wird, und
   - abgekühltes Gas über den Gasauslaß (30) aus dem Reaktor abgezogen wird, dadurch **gekennzeichnet**, daß
   - die Steigrohrwände (24) solcherart angeordnet sind, daß ein unterer Teil derselben das Brodelbett teilweise in einen Außen- und einen Innenteil aufteilt, wobei
   - Feststoffpartikel, die durch das Steigrohr in den oberen Bereich des Reaktors transportiert und aus dem abgekühlten Gas im Partikelabscheider im oberen Bereich des Reaktors abgeschieden sind, durch die Steigrohrwände (24) veranlaßt werden, zum Außenteil des Brodelbetts zurückzufließen und in das heiße Eintrittsgas eingeführt zu werden, nachdem die Partikel vom Außenteil (12') des Brodelbetts zum Innenteil (12") des Brodelbetts gewandert sind, und
   - Wärme aus Feststoffpartikeln durch im Strömungspfad der Feststoffpartikel angeordnete Wärmeübertragungsflächen zurückgewonnen wird, die über Steigrohr (22), Partikelabscheider (28), Rückführkanal (36) und Außenteil (12') des Brodelbetts (14) zum Innenteil (12") des Brodelbetts befördert werden.

2. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß Feststoffpartikel vom Innenteil (12") der Wirbelschicht als Überlauf über eine Kante (18) in die Heißgase eingeführt werden.

3. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß Feststoffpartikel vom Innenteil (12") der Wirbelschicht durch Öffnungen (60) des Einlaßkanals bei Anwendung eines Trägergases in die Heißgase eingeführt werden.

4. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß Feststoffpartikel auf Wärmeübertragungsflächen (44) abgekühlt werden, die im

Rückführkanal (36) angeordnet sind.

5. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß Feststoffpartikel auf Warmeübertragungsflächen (46) in der Wirbelschicht (14) abgekühlt werden.

6. Verfahren nach Anspruch 5, dadurch **gekennzeichnet**, daß Feststoffpartikel auf Wärmeübertragungsflächen (46) im Außenteil (12') des Brodelbetts abgekühlt werden.

7. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß die Gasströmung vom Steigrohr (22) in zwei, vorzugsweise in eine Vielzahl Partikelabscheider (28) geleitet wird, von wo die abgeschiedenen Feststoffpartikel über zwei, vorzugsweise eine Vielzahl Rückführkanäle (36), zum Brodelbett (14) zurückgeführt werden.

8. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß die Gasströmung durch den Einlaßkanal (16) in den unteren Bereich des Reaktors auf dem Niveau oder oberhalb der Düsen (52) eingeführt wird zur Einführung von Fluidisierungsgas in die Wirbelschicht (14).

9. Verfahren nach Anspruch 8, dadurch **gekennzeichnet**, daß die Gasströmung durch den Einlaßkanal (16) in den unteren Bereich des Reaktors auf dem Niveau der Düsen (52) eingeführt wird zur Einführung von Fluidisierungsgas in die Wirbelschicht (14).

10. Vorrichtung zur Abkühlung von Heißgasen in einem Reaktor (10), wo der untere Bereich des Reaktors mit einem Heißgaseinlaßkanal (16) und einer eine Wirbelschicht einschließenden Kammer (12) versehen ist, der mittlere Bereich mit einem Steigrohr (22) und der obere Bereich mit einem Gasauslaß (30) versehen ist, und der Reaktor Wärmeübertragungsflächen (24, 44, 46) zur Rückgewinnung von Wärme aus Feststoffpartikeln aufweist,
dadurch **gekennzeichnet**, daß der Reaktor umfaßt

- ein durch Wände (24) gebildetes Steigrohr (22), das über dem Brodelbett (14) derart angeordnet ist, daß der untere Abschnitt der Steigrohrwände (24) die Wirbelschicht teilweise in einen Außenteil (12') und einen Innenteil (12") aufteilt,
- zumindest einen Partikelabscheider (28), der im oberen Bereich des Reaktors angeordnet ist,
- zumindest einen Rückführkanal (36), um den Partikelabscheider (28) mit dem Außenteil (12') der Wirbelschicht zu verbinden, um die im Partikelabscheider abgetrennten Feststoffpartikel dem Außenteil der Wirbelschicht rückzuführen, und
- im Strömungspfad der Feststoffpartikel angeordnete Wärmeübertragungsflächen, der durch Steigrohr, Partikelabscheider, Rückführkanal und Außenteil der Wirbelschicht und dem Innenteil der Wirbelschicht gebildet wird.

11. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Rückführkanal (36) konstruktionsmäßig mit dem Steigrohr (22) verbunden ist, so daß die Steigrohrwand (24) einen Teil der Rückführkanalwand bildet.

12. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der obere, die Wirbelschicht (14) einschließende Bereich der Kammer (12) die Form eines offenen Bottiches hat.

13. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß das Brodelbett (14) in der ringförmigen Kammer angeordnet ist, die den Gaseinlaßkanal (16) umschließt.

14. Vorrichtung nach Anspruch 13, dadurch **gekennzeichnet**, daß das Steigrohr (22) zylindrisch ist und daß der Rückführkanal (36) einen schmalen Ringraum um das Steigrohr bildet.

15. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Gaseinlaßkanal (16) ein schmaler rechteckiger Schlitz ist und daß das Brodelbett von dem länglichen Bottich (12) aufgenommen wird, der neben dem schmalen Schlitz angeordnet ist.

16. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß das Brodelbett in den länglichen Bottichen enthalten ist, die auf beiden Seiten des schmalen Schlitzes angeordnet sind.

17. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Innenteil (12") des Brodelbetts mit Mitteln (18) zur Beförderung von Feststoffpartikeln als Überlauf in das heiße Eintrittsgas versehen ist.

18. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Innenteil (12") des Brodelbetts mit Mitteln zur Beförderung von Feststoffpartikeln mittels eines Trägergases über Einlaßöffnungen (60) in das heiße Eintrittsgas versehen ist.

19. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Außenteil (12') der Wirbelschicht mit Wärmeübertragungsflächen (46) zur Abkühlung von Feststoffpartikeln versehen ist.

20. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß der Partikelabscheider (28) durch übliche Wandkonstruktionen mit dem Steigrohr (22) verbunden ist.

21. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß sich der Heißgaseinlaßkanal (16) in die Kammer (12) bis auf das Niveau oder bis über die Düsen (52) zur Einführung von Fluidisierungsgas in die Wirbelschicht (14) erstreckt.

22. Vorrichtung nach Anspruch 21, dadurch **gekennzeichnet**, daß sich der Heißgaseinlaßkanal (16) in die Kammer (12) bis aufs Niveau der Düsen (52) zur Einführung von Fluidisierungsgas in die Wirbelschicht (14) erstreckt.

23. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß im Rückführkanal (36) Wärmeübertragungsflächen (44) zur Abkühlung von Feststoffpartikeln vorgesehen sind.

24. Vorrichtung nach Anspruch 10, dadurch **gekennzeichnet**, daß Wärmeübertragungsflächen (24, 74) zur Abkühlung von Feststoffpartikeln mit dem Steigrohr (22) verbunden sind.

Revendications

1. Procédé de refroidissement de gaz chaud dans un réacteur (10) dans lequel

   - la section inférieure du réacteur est pourvue d'un conduit d'admission de gaz chaud (16) et d'une chambre(12) renfermant un lit fluidisé dense (14), la section médiane est pourvue d'une conduite montante (22) définie par des parois (24), et la section supérieure comportant un séparateur de particules (28) et un orifice de sortie de gaz (30), et le réacteur comporte des surfaces de transfert thermique (24, 44, 46) pour récupérer la chaleur à partir des particules solides, de sorte que
   - le gaz chaud est introduit par le conduit d'admission (16) dans la section inférieure du réacteur,
   - les particules solides provenant du lit fluidisé dense (14) sont amenées dans le gaz chaud pour le refroidir;
   - les particules solides sont séparées du gaz contenant des solides ainsi refroidi et renvoyées au lit fluidisé dense,
   - le gaz contenant des solides refroidi est conduit par la conduite montante (22) dans la section supérieure du réacteur, où les particules solides sont séparées du gaz dans le séparateur de particules (28) et renvoyées vers le lit fluidisé dense,
   - la chaleur est récupérée à partir des particules solides séparées dans le lit fluidisé dense, et
   - le gaz refroidi est évacué hors du réacteur par l'orifice de sortie de gaz (30)

   caractérisé en ce que

   lesdites parois de la conduite montante (24) sont agencées de telle sorte qu'une partie inférieure de ces parois sépare partiellement le lit fluidisé dense en une partie extérieure et une partie interne, de façon que

   - les particules solides, qui sont transportées par la conduite montante dans la section supérieure du réacteur et séparées du gaz refroidi dans le séparateur de particules de la section supérieure du réacteur, sont entraînées par lesdites parois de la conduite montante (24) pour être renvoyées vers la partie extérieure du lit fluidisé dense et pour être conduites dans le gaz d'admission chaud après que lesdites particules ont circulé de ladite partie extérieure (12') du lit fluidisé dense vers la partie interne (12") du lit fluidisé dense, et
   - la chaleur est récupérée à partir des particules solides à l'aide des surfaces de transfert thermique disposées dans le parcours de circulation des particules solides lors de leur transport par la conduite montante (22), le séparateur de particules (28), une conduite de retour (36) et la partie extérieure (12') du lit fluidisé dense (14) vers la partie interne (12") du lit fluidisé dense.

2. Procédé selon la revendication 1, caractérisé en ce que les particules solides provenant de la partie interne (12") du lit fluidisé sont amenées par débordement le long d'une bordure (18) dans les gaz chauds.

3. Procédé selon la revendication 1, caractérisé en ce que les particules solides venant de la partie interne (12") du lit fluidisé sont introduites dans les gaz chauds à travers des ouvertures (60) du conduit d'admission en utilisant un gaz de transport.

4. Procédé selon la revendication 1, caractérisé en ce que les particules solides sont refroidies sur les surfaces de transfert thermique (44) disposées dans la conduite de retour (36).

5. Procédé selon la revendication 1, caractérisé en ce que les particules solides sont refroidies sur les surfaces de transfert thermique (46) dans le lit fluidisé (14).

6. Procédé selon la revendication 5, caractérisé en ce que les particules solides sont refroidies sur les surfaces de transfert thermique (46) dans la partie extérieure (12') du lit fluidisé dense.

7. Procédé selon la revendication 1, caractérisé en ce que le courant de gaz est conduit de la conduite montante (22) dans deux, de préférence dans une pluralité de, séparateurs de particules (28) à partir desquels les particules solides séparées sont renvoyées par l'intermédiaire de deux, de préférence d'une pluralité de, conduites de retour (36) au lit fluidisé dense (14).

8. Procédé selon la revendication 1, caractérisé en ce que le courant de gaz est introduit par la conduite d'admission (16) dans la section inférieure du réacteur au même niveau que, ou au-dessus du niveau des buses (52), pour introduire le gaz de fluidisation dans le lit fluidisé (14).

9. Procédé selon la revendication 8, caractérisé en ce que le courant de gaz est introduit par la conduite d'admission (16) dans la section inférieure du réacteur au niveau égal au niveau des buses (52) pour introduire le gaz de fluidisation dans le lit fluidisé (14).

10. Dispositif pour refroidir des gaz chauds dans un réacteur (10) dans lequel la section inférieure du réacteur est pourvue d'une conduite d'admission de gaz chaud (16) et d'une chambre (12) renfermant un lit fluidisé, la section médiane est pourvue d'une conduite montante (22), et la section supérieure comportant un orifice de sortie de gaz (30), et le réacteur possède des surfaces de transfert thermique (24, 44, 46) pour récupérer la chaleur à partir des particules solides,

caractérisé en ce que

le réacteur comprend

- une conduite montante (22) définie par des parois (24) et disposée au-dessus du lit fluidisé dense (14), de façon que la partie inférieure des parois de la conduite montante (24) divise partiellement le lit fluidisé en une partie extérieure (12') et une partie interne (12"),
- un séparateur de particules (28), au moins, disposé dans la section supérieure du réacteur,
- une conduite de retour (36), au moins, pour connecter le séparateur de particules (28) à la partie extérieure (12') du lit fluidisé, pour renvoyer les particules solides séparées dans le séparateur de particules vers la partie extérieure du lit fluidisé, et
- des surfaces de transfert thermique disposées dans le parcours de circulation des particules solides, tel que défini par la conduite montante, le séparateur de particules, la conduite de retour et la partie extérieure du lit fluidisé et la partie interne du lit fluidisé.

11. Dispositif selon la revendication 10,

caractérisé en ce que

la conduite de retour (36) est connectée structuralement à la conduite montante (22) de sorte que la paroi de la conduite montante (24) constitue une partie de la paroi de conduite de retour.

12. Dispositif selon la revendication 10, caractérisé en ce que la section supérieure de la chambre (12) renfermant le lit fluidisé (14) présente la configuration d'une cuve ouverte.

13. Dispositif selon la revendication 10, caractérisé en ce que le lit fluidisé dense (14) est disposé dans la chambre annulaire renfermant la conduite d'admission de gaz (16).

14. Dispositif selon la revendication 13, caractérisé en ce que la conduite montante (22) est cylindrique et en ce que la conduite de retour (36) forme un espace annulaire étroit autour de la conduite montante.

15. Dispositif selon la revendication 10, caractérisé en se que la conduite d'admission de gaz (16) est une fente rectangulaire étroite et en ce que le lit fluidisé dense est contenu dans la cuve de forme allongée (12) disposée de façon adjacente à la fente étroite.

16. Dispositif selon la revendication 10, caractérisé en ce que le lit fluidisé dense est contenu dans les cuves de forme allongée disposées sur les deux côtés de la fente étroite.

17. Dispositif selon la revendication 10, caractérisé en ce que la partie interne (12") du lit fluidisé dense est pourvue des moyens (18) pour faire passer les particules solides, par débordement dans le gaz d'admission chaud.

18. Dispositif selon la revendication 10, caractérisé en ce que la partie interne (12") du lit fluidisé dense est pourvue des moyens pour acheminer les particules solides par l'intermédiaire d'un gaz de transport à travers les ouvertures d'admission (60) dans le gaz d'admission chaud.

19. Dispositif selon la revendication 10, caractérisé en ce que la partie extérieure (12') du lit fluidisé est pourvue des surfaces de transfert thermique (46) pour refroidir les particules solides.

20. Dispositif selon la revendication 10, caractérisé en ce que le séparateur de particules (28) est connecté à la conduite montante (22) par des constructions de parois communes.

21. Dispositif selon la revendication 10, caractérisé en ce que la conduite d'admission de gaz chaud (16) s'étend dans la chambre (12) jusqu'au même niveau que ou au-dessus du niveau des buses (52) pour introduire le gaz de fluidisation dans le lit fluidisé (14).

22. Dispositif selon la revendication 21, caractérisé en ce que la conduite d'admission de gaz chaud (16) s'étend dans la chambre (12) au même niveau que le niveau des buses (52) pour introduire le gaz de fluidisation dans le lit fluidisé (14).

23. Dispositif selon la revendication 10, caractérisé en ce que les surfaces de transfert thermique (44) sont pourvues dans la conduite de retour (36) pour refroidir les particules solides.

24. Dispositif selon la revendication 10, caractérisé en ce que les surfaces de transfert thermique (24, 74) sont associées à la conduite montante (22) pour refroidir les particules solides.

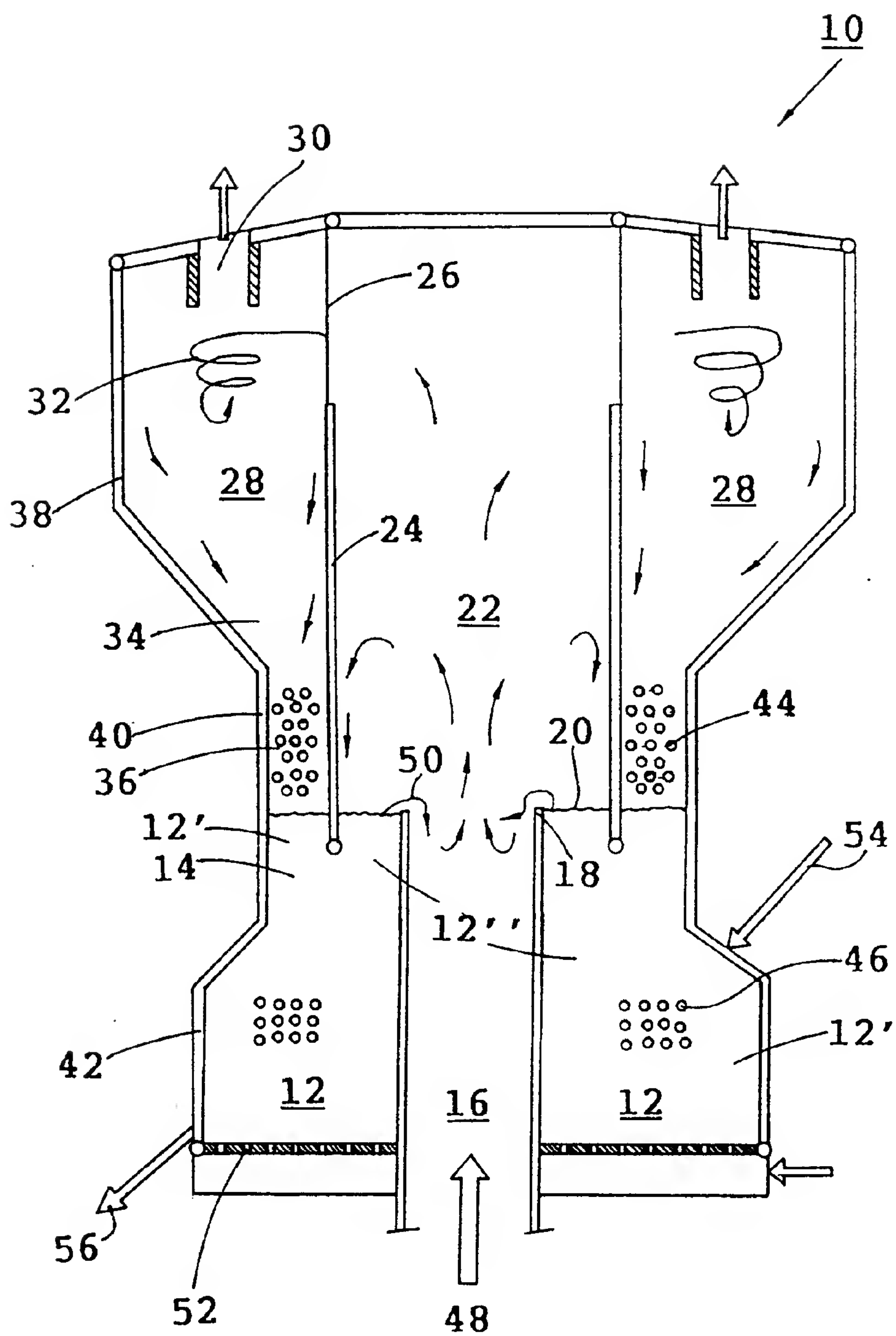
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FIG. 1

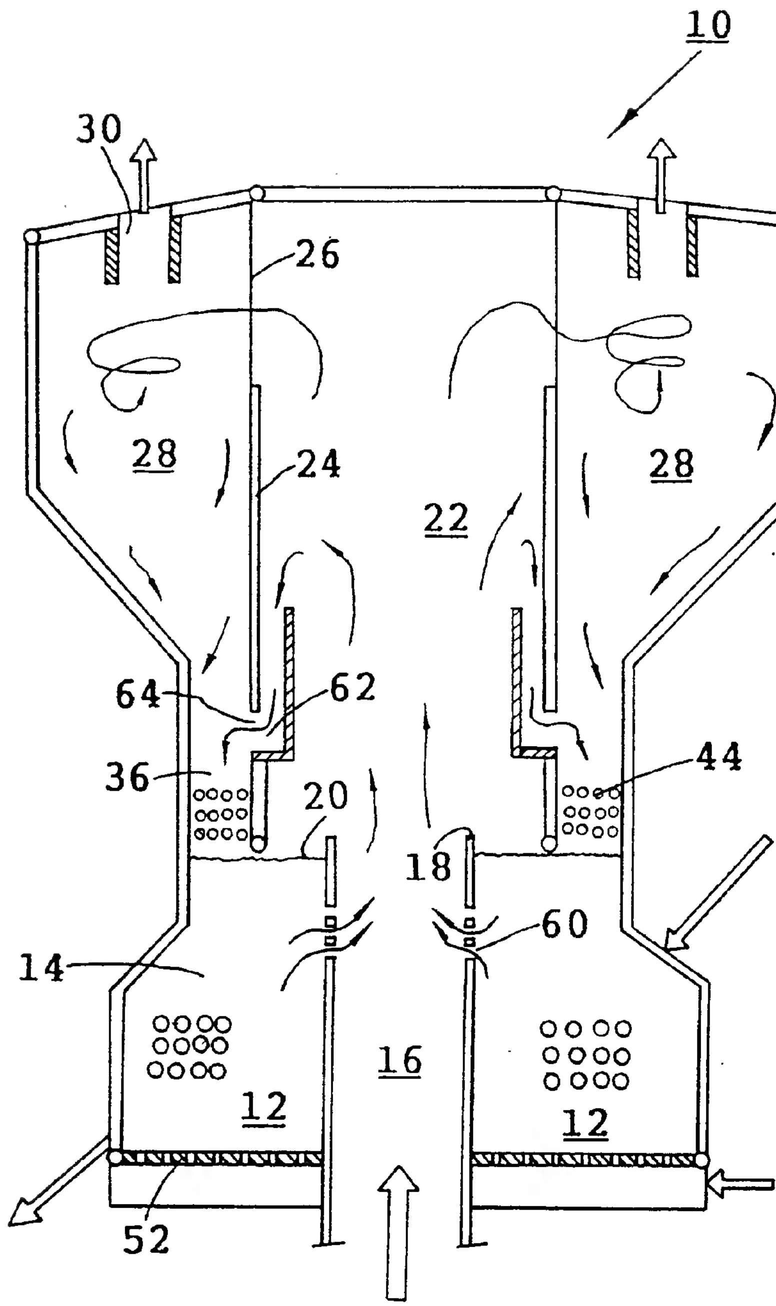

FIG. 2

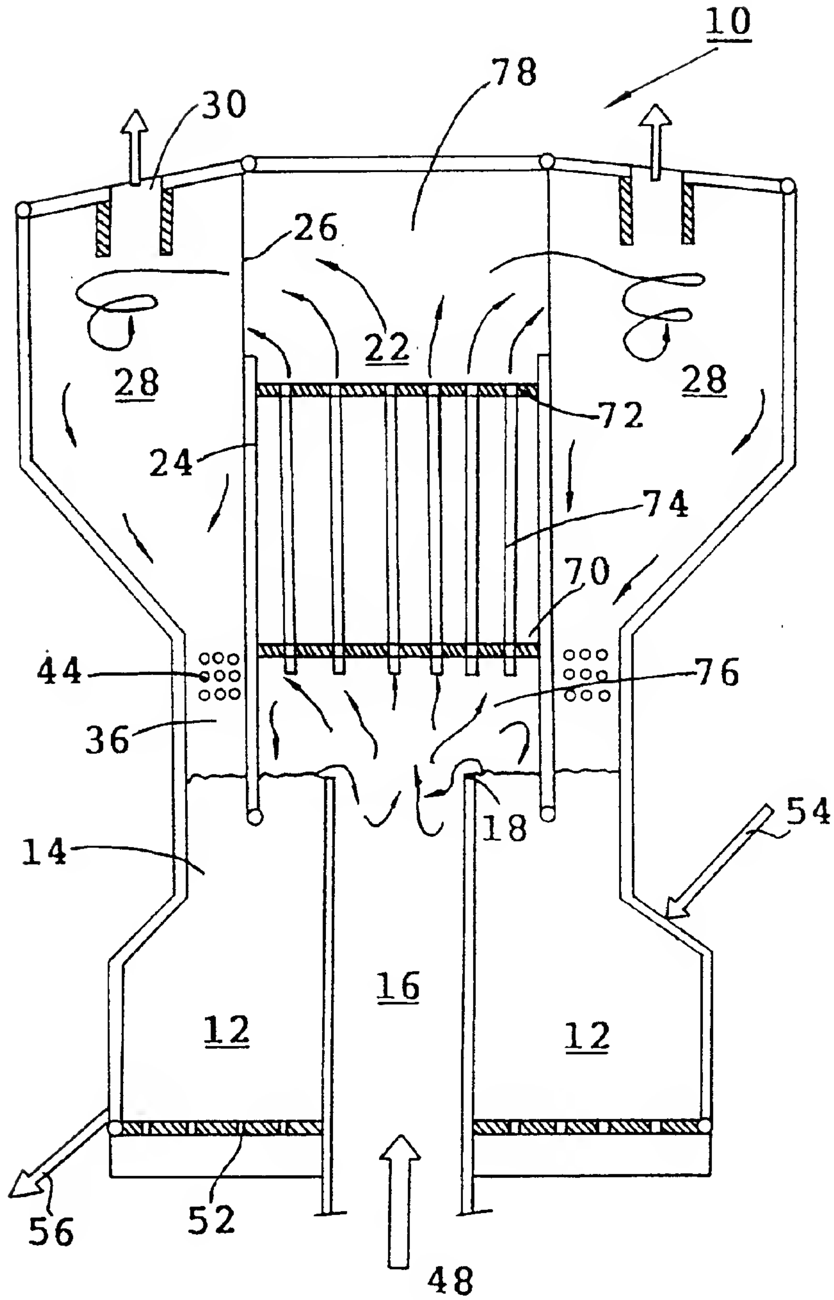

FIG. 3